S. J. B

A. M. D. G.

# BULLETIN

*of the*

# American Association of Jesuit Scientists

(Eastern Section)

Founded 1922

Published at

LOYOLA COLLEGE

BALTIMORE, MARYLAND

VOL. XVII MARCH, 1940 NO. 3

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# Bulletin of American Association of Jesuit Scientists

EASTERN STATES DIVISION

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# SCIENCE AND PHILOSOPHY

## THE EPISTEMOLOGICAL CRISIS IN MODERN SCIENCE

REV. JOSEPH P. KELLY, S.J.

In the past few years we have heard much about the decline of materialism, as a fundamental philosophy of the Natural Sciences. Most of the scientists accept this fact and for some, it has offered a reason for indulging in philosophical speculation. Classical Physics, for the most part, was based on the supposition that all natural phenomena could be sufficiently explained in terms of matter and motion, determined in time and space. It cannot be denied that with this philosophy the scientists attained remarkable success in the interpretation of the universe. The hidden secrets of nature became almost household knowledge. The result was the magnificent conception of a well-ordered world, operating with machine-like precision, capable of being foreseen and anticipated, when one had an adequate cognition of certain antecedent conditions. As time went on, the increasing perfection of the scientific methods and the rapid development of the system were apparently bringing this idealized universe closer and closer to realization. But by a strange irony of fate or a perversity that so often occurs in human affairs, this same philosophy on which the scientist had builded so well, was proving itself more and more inadequate as he probed deeper the inner workings of nature.

### The Crisis

Hence arose the crisis in scientific thought. For it was soon realized that many of the principles and theories that seemed so convincing in 19th century Physics were found wanting when applied to the discoveries of the 20th century. The precise operation of the macrocosmic order, so well predicted and predictable, failed to function with the same ease in the microscopic order. This situation caused the men of science to reconsider their position with a view to formulating new principles and a new outlook on the world. Much effort has been spent on this task and one of the chief questions was the approach to and the knowledge of reality, lest the future bring us face to face with another crisis like the present one. Science must not experience another "breakdown of Materialism." Thus, "we must make it our business to understand so thoroughly the character of

our permanent mental relations with nature that another change in our attitude such as that due to Einstein, shall be forever impossible." (1). Reflection on this purpose shows us that the focal-point of the relations between Science and Philosophy has been shifted to the field of Epistemology. The present outlook deals with knowledge of reality and the process of obtaining it.

Let us examine the problem more closely. It is constantly asserted that the building stones of science are "hard, stubborn facts." The object of the natural sciences is to correlate these facts and to formulate the laws that govern their behavior. The ultimate goal is a consistent system of thought embracing the whole of the universe, just as the theory and laws of gravity embrace and unify all the phenomena connected with gravitation. That this system should bear some definite relation to the external world, all will admit, although the savants disagree when they attempt to define precisely what this relationship really is. Now, since the time of Galileo, science, at least in practise, has rejected the "qualitative" interpretation of nature. It is agreed that the natural sciences should treat of those properties of the physical world which are susceptible to measurement and capable of being expressed in mathematical or numerical terms. This is the meaning of the phrase: "science is quantitative." Hence, the scientist will discuss the size and motion of the earth, stellar distances, atomic weights, etc., etc. These are measurable elements in the universe of the scientist. They can be expressed quantitatively, in numerical terms and in mathematical formulas. That this point of view still holds among the moderns may be seen from some citations. Planck defines a Physical Law as: "a proposition enuntiating a fixed and absolutely valid connection between *measurable*, physical quantities." (2). Heisenberg, the author of the Uncertainty Principle affirms that only the *observables* and the *measurables* should be considered in the formulation of a physical theory. (3). Einstein takes the ultimate step in asserting that what cannot be *observed* does not exist (for the scientist). Commenting on the negative results of the Michelson-Morely experiment for the measurement of the "ether-drift", Einstein asks: "if a thing cannot be observed why is it necessary to assume its existence?" (4). Thus, scientifically speaking, the "criterion of objective, physical existence is the general observability by physical means." (5). By the same token, what is non-observable or non-measurable by some physical means (experimentally) has no existence in the scientific order of things. Those concepts which refer to and which represent non-

(1) Bridgman. "The Logic of Modern Physics." p. 2. He here refers to the profound changes in the concepts of time and space brought about by the Theory of Relativity.
(2) Planck. "The Universe in the Light of Modern Physics". p. 62.
(3) "Atomic Physics". Physics Staff, Univ. of Pittsburgh, p. 259.
(4) Bridgman. "The Nature of Physical Theory". p. 64 sq.
(5) Dingle. "Nature". May 4, 1935, p. 676. c.f. also, Note.

quantitative objects have no objective validity *in science.* We emphasize the words, *in science,* because in their "philosophical" writings, we find these same authors employing many non-quantitative terms, as do their fellow-men who are not "ex professo" scientists. (6). If such terms have no validity and are in general meaningless words, we are left with the obvious conclusion that they are talking sheer nonsense. To avoid pronouncing so harsh a judgment on them, we make the distinction between the use of these terms, "in science" and "elsewhere." Perhaps we might adopt the Einsteinian distinction between the scientist who speaks "as a scientist" and the scientist who speaks "as a literateur". (6a).

### Meeting The Crisis Scientifically

The trend of scientific thought on the problem of reality and the outlook on its physical existence has given rise to the "Operational Viewpoint", so ably propounded by Bridgman. (7). Its avowed purpose is, according to this eminent physicist, to eliminate from the physical sciences all material of a speculative nature and to reject all conclusions which cannot be tested by physical means. This is quite in keeping with the general tenor of the sciences. For, the test of any speculation, i.e., a physical *theory,* is that its predictions agree with experimental results. The position is easily admissable. The Operational Viewpoint is the deliberate attempt to limit, in principle, the scope of the physical sciences to the purely quantitative aspects of nature. By concentrating his efforts on this field, the scientist hopes to avoid matters which might lead to another crisis in scientific thought. But, on the other hand, it introduces the Epistemological question of our knowledge of the material universe. For, Bridgman tells us that according to the point of view, "we shall no longer permit ourselves to use as tools in our thinking, concepts of which we cannot give an adequate account in terms of operations." (8). This outlook, it would seem, is the culmination of a process long in existence. In 1870 Maxwell wrote: "As science has been developed, the domain of quantity has everywhere encroached on that of quality, until the process of scientific inquiry seems to have become simply the *measurement* and the registration of quantities combined with the mathematical discussion of the numbers obtained." (9). Planck seems to re-echo these sentiments when he writes: "There is only one sure guide towards further development and that is *meas-*

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(6) c.f. Planck. "Where is Science Going?" passim.
Einstein. "The World as I See It." passim.

(6a) Planck. op. cit. p. 213.

(7) Bridgman. "The Logic of Modern Physics."

(8) Bridgman. "Logic of Modern Physics." p. 31.

(9) Quoted from O'Rahilly. "Electromagnetics." p. 757.

(10) Planck. "The Universe in the Light of Modern Physics." p. 78.

*urement,* together with any logical conclusions that can be drawn from *concepts attached to this method.*" (10).

In the light of the foregoing, it follows that the only true knowledge of the universe is to be found in those concepts which represent some sort of a physical operation. To put it in another way, we can know only those objects which can be observed by physical means, which in the words of the authors cited, comes to some process of measurement. It would follow further that such terms as essence, causality, being and substance constitute a purely nominalistic vocabulary. For, they are non-quantitative and as such cannot enter into the domain of science. They cannot be tested by experimental means; they have no corresponding "operation." It is true that the scientist sometimes employs these terms but not in the traditional sense of the word. He gives them a quantitative signification, quite differerent from their ordinary or philosophical meaning. For example, in Scholastic philosophy the term "causality" denotes that necessary nexus between the agent producing and the result produced. It is forced on the intellect by the principle of sufficient reason. We cannot directly observe it through the senses nor measure it; is is essentially non-quantitative. But when the scientist speaks of causality, he generally means the "invariable sequence of events" in nature. This sequence can be observed in a spacio-temporal situation. The antecedent phenomenon can be so correlated to the consequent that the latter may be predicted with a high degree of accuracy and expressed in mathematical terms. There is a vast difference between the two notions. While the latter is accepted as a valid, scientific concept, the former can have no place in the "Operational" scheme of thought. Thus the "Operational Viewpoint" tends to destroy that community of language and the common understanding between science and philosophy. For, in this system, the scientist, cannot admit the legitimacy and the objective validity of a host of philosophical concepts because they cannot be tested or proved by the criteria of this system. Hence, to propose such philosophical questions as: "Was there ever a time when matter did not exist?" or "Can time have a beginning and an end?", is to ask a meaningless question. There is no physical means to prove or to disprove them. (10).

While it is true that there is a general acceptance of the "Operational Viewpoint" among the scientists, some have been unwilling to hold this extreme view. They are not willing to follow the principles of this system to the logical conclusion. It offers many difficulties and closes certain fields of investigation. They feel that there should be full freedom to investigate any avenue. Yet, the logical consequence of the fundamental principle that "only the observables and

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(10) Bridgman. op. cit. ult. p. 30. Here the author explains why these and many other questions are meaningless to the scientist.

the measurables are to be admitted in science", is that it places necessary limits on the researches of physical science. Others feel that the doctrine of the "observables" is really impossible in practise because of the difficulty in defining and delimiting the notion in the physical sense of the term. The following reveals that this system is not altogether acceptable among the scientists. "In fact, we may well ask what an observable is, and if we go at all beyond the direct sensations, which as physicists we certainly intend to do, the answer becomes perfectly indefinite. . . . Professor Ehrenfest said: "To believe that one can make physical theories without metaphysics and without unobservable quantities, that is one of the diseases of childhood." (11). This point of view is in open contradiction to the "Operational Viewpoint."

### Some Philosophical Aspects

From a philosophical point of view, the scientific solution of the crisis is definitely inadequate. In the ultimate analysis, it is a step backwards. For, the cult of the observables and the measurables pushes us back to the days of the English Empiristic School, which held that "experience is the sole criterion of knowledge". The present "Operational" principle admits but one norm and this is likewise experience. For, the observables and the measurables are those things which are attainable through the senses. Philosophy cannot admit that there is but one criterion of knowledge. No philosophy would deny that the senses are a source of cognition and a true font of knowledge under certain conditions. But it would be philosophical suicide to attempt to erect a system of thought *solely* on the experience of the senses. The history of philosophical thought of the past century has given ample evidence of the failure of this principle and *the basic principle* of philosophy. We clearly recognize that there are many scientists who hold and use the "Operational" principle as a methodology in science; that they limit its use to the natural sciences. With these there is no quarrel. However, one has but to read the philosophical excursions of many eminent scientists of to-day and the writings of some modern philosophers to realize that there is a great unwillingness to restrict this principle to the methods of science. There is a definite attempt to extend it beyond the confines of the natural sciences and extrapolate it into other branches of knowledge, and especially into philosophy. It is unwarranted and unacceptable. There is a wide field of knowledge in the metaphysic and the metempiric, concepts and principles which have their objective validity independently of scientific criteria. The methodology of the natural sciences, valuable though it be in its proper camp, is too narrow and confined to satisfy the natural tendencies and capacities of the human intellect. As Eddington well remarks: "We recognize that the type of knowledge after which physics is striving is

(11) Darwin, in "Science." Aug. 19, 1938. p. 157.

much too narrow and specialized to constitute a complete understanding of the environment of the human spirit. A great many aspects of our ordinary life take us outside the outlook of physics. For the most part no controversy arises as to the admissibility and importance of these aspects; we take their validity for granted and adapt our lives to them without any deep self-questioning." (12). If we keep this distinction in mind in dealing with the "Operational Viewpoint" and other proposed solutions of the problem of knowledge, we shall have little trouble avoiding a great many Epistemological difficulties that arise in discussing borderline questions between Science and Philosophy.

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(12) Eddington. "New Pathways of Science." p. 316.

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# ASTRONOMY

## NOTE.—FUNDAMENTAL CONSTANTS

In the December issue of the BULLETIN there was an item concerning the very exacting requirements laid down by the U. S. Government for appointment to the post of Director of the American Nautical Almanac Office: in this connection it is of interest to note the great influence that has been exercised by this Office on the Nautical Almanacs not only of America but of the whole world. In 1911 there was held in Paris a meeting of the representatives of most of the countries which publish Nautical Almanacs; in this Congrès International des Ephémérides Astronomiques the outstanding character of the work done here in this field was recognized and since then, in accordance with the recommendations of that Congress, most of the material common to the various great national Almanacs is based on Tables prepared by the American Office, and these Tables rest on the fundamental constants determined by American Scientists; to a great extent, also, these Tables have been drawn up according to the methods and the formulae of computation developed or modified in the United States. The following is the list of these fundamental constants:

General Precession—value determined by Simon Newcomb (of the American Nautical Almanac Office)
Speed of rotation of the Ecliptic—Newcomb
Longitude of Axis of rotation of the Ecliptic—Newcomb
Obliquity of the Eclipctic—Newcomb
The Moon's Equatorial horizontal parallax—Ernest W. Brown (Yale Univ.)
Velocity of Light—Newcomb and Michelson
Length of the Year—Newcomb
Length of the Month—Brown
Dimensions of the Earth—those of the Hayford Spheroid (U. S. Coast and Geodetic Survey Office)

About the only fundamental astronomical constant not credited to the U. S. is the gravitational constant and acceleration due to gravity.

As to the Ephemerides themselves—those of the Sun are derived from Newcomb's Tables of the Sun;

those of the Moon, chiefly from Brown's Tables of the Moon;

those of Mercury, Venus and Mars from Newcomb; of Jupiter and Saturn from Hill's Tables (Am. Nautical Almanac Office) of Uranus and Neptune from Newcomb.

Dr. Robertson (mentioned in the December issue) is a leading authority on the theory of the Satellites of Jupiter and his Elements of the Vth. Satellite have been adopted for the determination of the elongation of this Satellite.

Some other particular elements and constants for the planets were determined by American astronomers.

It would be foolish as well as false to claim for the United States a monopoly in astronomical science; but the above list of astronomical achievements proves the high value of both the theoretical and the practical work done in the past and still being done by American Scientists.

E. C. P., S.J.

# CHEMISTRY

## A YEAR'S ADVANCE IN CHEMISTRY

REV. RICHARD B. SCHMITT, S.J.

The arrival of the new year again calls for a brief retrospect of the progress of chemistry. This yearly short review of chemical progress is principally intended for our professors of philosophy. Since science and philosophy are so intimately related and since new discoveries in chemistry are so numerous, it should be helpful to the philosophers to know the most recent outstanding scientific facts about mass and energy, about the transmutation of atoms and molecules.

The outstanding discovery in 1939 was the splitting of the uranium atom with the release of enormous amounts of energy, and the transmutation of this element into new radio active elements, some of which are heavier than uranium and others that have atomic weights less than uranium. Professor Enrico Fermi of Rome, now of Columbia University, claims there are four elements from uranium that are heavier than uranium. Uranium is the last element in the perodic table, and has an atomic number of 92. These newly discovered elements are numbered 92, 93, 94 and 95 and called eka-rhenium, eka-osmium, eka-iridium and eka-platinum. This transmutation is brought about by bombarding uranium with neutrons.

Heavy carbon, with the atomic weight 13, is now used for tracing bodily functions in the human system, and will give new information about vital processes.

A new theory of chemical combination was advanced by Dr. George Calingaert, director of chemical research for the Ethyl Gasoline Corporation, in which it was shown that instead of a single combined form resulting from the mixture of two chemical substances, a number of other substances appeared and these were governed by the laws of chance.

### Medical Triumphs of 1939

The sulfanilamide derivatives, of which sulfapyridine is perhaps the most conspicuous example because of the marvels that it performs in pneumonia, continued to make spectacular progress. Two of the more remarkable of these are sulfathiazol and sulfamethylthiazol. Both are as effective as sulfapyridine in pneumonia, but preferable because they are not so nauseating and toxic,

Important, too, is the new drug solbisminol, which, though first compounded in 1936, nevertheless must be credited to 1939 because only recently was it accepted as of value in the treatment of syphilis. Solbisminol, the discovery of Professor Hanslick of Stanford, is the first antisyphilitic that can be taken by mouth. It looks like a chocolate powder and comes in capsules.

A new way of detecting thyroid gland disorders and of differentiating excessive activity of the gland from diabetes has been worked out at the Medical School of the University of California. Galactose, a kind of sugar not normally found in the blood, is the test reagent. It is easily distinguished from glucose, the kind of sugar usually present in the blood. By tracing galactose from the stomach into the blood it is possible to determine whether thyroid activity is abnormally high or low.

The method was developed by Dr. T. L. Althausen. For it he received the Van Meter prize of the American Association for the Study of Goiter. He found that thyroxin, which is secreted by the thyroid gland, speeds up the movement of sugar through the walls of the stomach and intestines into the blood, so that apparent excesses accumulate. A hyperthyroid gland will use up or throw off this excess sugar. Some of it excreted by the kidneys, so that a wrong diagnosis of diabetes is excusable.

Vitamin K, the blood-clotting vitamin, was added to the lists of vitamins produced synthetically. Its structure was determined by Dr. E. A. Doisy of St. Louis University Medical School, and its synthesis was prepared by Dr. L. F. Fieser, of Harvard.

A chemical from cultures of soil bacteria, has been found to be a powerful destroyer of pneumonia germs in tests on animals. It has been found effective against other positive bacilli, including the important staphlococci group, and those which cause tetanus, anthrox and tuberculosis.

The female sex hormone, esterone, was made synthetically by Dr. Werner E. Bachman, Dr. J. Wayne Cole and Dr. Alfred L. Wilde, of the University of Michigan. Other synthetic vitamins now on the market are $B_1$ $B_2$ $B_6$ C E K, nicotinic acid and riboflavin.—Gallium was discovered to be essential to life processes in minute quantities.

### Industrial Progress

The glass industry developed a safety glass, a glass that bends and is non-shatterable. The rubbery glass that bends is a poly vinyl acetal plastic. Another product was developed by the Corning Glass Works, which is a borosilicate glass and can be heated to cherry red and then plunged into ice-water without breaking. By chemical treatment this glass becomes 96% pure silica. Fiberglass is now used for insulating electric motors.—Hollow glass blocks are improved; also glass cooking utensils.—A glass writing board for school room use has been perfected. It has little reflection from the surface, is adapted to use with chalk or crayon, and comes in various colors.—Polaroid

glass is used for non glare surfaces.—Fluorescent lamps have been made very efficient.

The metallurgists have also made many advances in their special field. It was found that a small amount of silver in stainless steel will lessen salt water corrosion. Titanium tetrachloride gives stainless steel a lustrous finish with a smooth surface and resistant to pit corrosion.

Another outstanding feature of industrial chemistry is the progress made in synthetic fibers. For the past two years, the foreign countries developed many new fibers, and our chief interests were in perfecting the rayon fibers. Most of these products were made from some form of cellulose, but the new fibers are a form of synthetic resins. A few of the important fibers now ready for manufacturing various products are:—Nylon, a research product of E. I. du Pont de Nemours and Co. laboratories; and they plan to produce 5,000,000 pairs of hose this year. Dermal sutures are also being made from Nylon and have been used in twenty hospitals with success. These sutures are dyed in various colors, so that they can easily be located. Bristles for nail and hair brushes are also made from this same chemical compound, which is a polyamide resin. There are five hundred dyes that can be used on nylon fiber.—Vinyon is a synthetic fiber made by Carbide and Carbon Chemicals Corporation. This synthetic fiber is particularly suitable for industrial filter presses, also for rain-coats, fish nets, sails for boats, etc. It is resistant to mineral acids, alkalies, and to molds and mildew.

The Standard Oil Development Company announced the production of elastic fibers from polyisobutylene; this product does not deteriorate so rapidly as rubber. The Dow Chemical Company is also developing a new fiber, which is a substitute for silk. Then, too, the Glidden Company is doing research on a synthetic fiber made from the soybean.

Many new products of rubber are now in use: foamed latex for seat cushions; a latex sheet for packing foods in bags that are odorless and tasteless, moisture proof, vapor proof and prevents evaporation; a thin perforated latex sheet for filtering purposes; kautex is a cork-rubber composition; anhydrex, an insulating material for cables; and new processes are in operation for reclaiming used rubber.

Many new plastics were also prepared for use in many manufactures. These plastics are fundamentally amine-aldehyde resins, resins from wood pitch and formaldehyde, phenolics, dihyronapthalenes, ureas and ploystyrene. At present there are hundreds of uses for these various plastics.

We have enumerated only a few of the new discoveries of the past year in the field of chemistry. A great many more are enumerated in the literature.

*"Scientific education is an essential condition to industrial progress".*

# SUGGESTED READING FOR CHEMISTRY STUDENTS

Rev. Joseph J. Sullivan, S.J.

The following is a list of books we have prepared as collateral reading for chemistry students. It has been revised and enlarged during several years and represents the contributions of several professors here along with advice from the College Librarian. As can be seen, it is not restricted to purely chemical topics, but branches out into biology, physics, even into medicine, as well as certain historical aspects of all branches of science. As we should wish, there are also titles concerned with commercial and technological applications of chemistry.

In general the books are of the popular variety and serve as gentle leading strings to lure the student into more abstruse excursions. They are kept in the Main library (Dinand Hall), for they have better facilities there for dispensing and displaying the books as well as plenty of reading-room for those who want to browse through the list. We might add, too, that reports from the Library justify us in this arrangement. It has facilitated a wide and gratifying circulation of these suggested readings.

### Suggested Reading for Chemistry Students
(Revised, October 1939)

Abel—Future Independence and Progress of Medicine (6 copies).
Alexander—Colloid Chemistry, An Introduction.
American Medical Association—Nostrums and Quackery.
Armitage—History of Chemistry.
Arrhenius—Chemistry in Modern Life.
Baker—The Universe Unfolding.
Barger—Some Applications of Organic Chemistry to Biology and Medicine.
Bashford—Harley Street Calendar.
Bayne-Jones—Man and Microbes.
Bell—The Queen of the Sciences.
Besredka—Immunity in Infectious Diseases.
Bishop—Panama Gateway.
Burr—Weir Mitchell.
Caldwell—Science Remaking the World.
Chamberlain—Chemistry in Agriculture (3 copies).
Chase—Your Money's Worth (4 copies).
Cohen—J. H. van't Hoff, Sein Wirken und Sein Leben.
Cohn—Chemistry in Daily Life (3 copies).
Columbia University—Contemporary Developments in Chemistry.
Compton—Genius of Louis Pasteur.
Cramp—Nostrums and Quackery.
Curie—Pierre Curie.
Cushing—Consecratio Medici (2 copies).
Dampier—History of Science.
Darrow—The Story of Chemistry.
Davis—Advance of Science (2 copies).
Davis—Science Today.
De Kruif—The Hunger Fighters.

De Kruif—Microbe Hunters (2 copies).
De Kruif—Seven Iron Men.
De Kruif—Why Keep Them Alive.
Deming—Realm of Carbon.
Descour—Pasteur and His Work (3 copies).
Deutsch—Mentally Ill in America.
Dock—Short History of Nursing.
Duclaux—Pasteur (2 copies).
Findlay—The Treasures of Coal Tar.
Foster—Romance of Chemistry.
His Daughters—Life of Sir Edward Frankland.
Furnas—The Next 100 Years.
Garbedian—March of Science.
Gerard—The Church versus Science.
Glasscock—Big Bonanza.
Glasscock—Gasoline Age.
Glasscock—War of the Copper Kings.
Grant—The Chemistry of Breadmaking.
Greenwood—Aladdin, U. S. A.
Gregory—Discovery, The Spirit and Service of Science (10 copies).
Harden—Alcoholic Fermentation.
Harrison—Atoms in Action.
Harrow—Eminent Chemists of Our Time.
Haskins—Studies in Mediaeval Science (2 copies).
Heiser—American Doctor's Odyssey.
Hilditch—A Concise History of Chemistry.
Holland—Industrial Explorers.
Hornady—Soldiers of Progress and Industry.
Howe—Chemistry in Industry.
Howe—Chemistry in the World's Work.
Hunter—Science Teaching.
Jaffe—Crucibles.
Jeans—The Universe Around Us (2 copies).
Jones—New Era in Chemistry (2 copies).
Kopeloff—Lactobacillus Acidophilus.
Kopeloff—Man versus Microbes.
Leonard—Crusaders of Chemistry.
Libby—History of Medicine.
London Chem. Soc.—Life and Work of Sir William Henry Perkin. (2 copies).
Lowry—Historical Introduction to Chemistry.
Malisoff—Meet the Sciences.
Martin—Modern Chemistry and Its Wonders.
Masson—Three Centuries of Chemistry.
Meoz—And Then Came Ford.
Moore—History of Chemistry.
Morgan—Keeping a Sound Mind.
Morrison—Man in a Chemical World (2 copies).
Nobel Institute—Life of Alfred Nobel.
O'Connor—The Guggenheims.
Paget—Confessio Medice (3 copies).
Paget—Pasteur and After.
Peck—Our World.
Reid—Great Physician.
Reymond, A.—History of Sciences in Greco-Roman Antiquity.
Roscoe—John Dalton.
Sarton—History of Science and the New Humanism.
Sheen—Philosophy of Science.

Singer—History of Medicine.
Slosson—Creative Chemistry (12 copies).
Stewart—Chemistry and Its Borderland.
Stieglitz—Chemistry and Progress in Medicine.
Stieglitz—Chemistry in Medicine (13 copies).
Strecker—Discovering Ourselves.
Sullivan—Limitations of Science.
Sutherland—Arches of the Years.
Sutherland—In My Path.
Sutherland—A Time to Keep.
Thompson—Quacks of Old London.
Thorpe—Essays in Historical Chemistry.
Tilden—Chemical Discovery and Invention in the 20th Century.
Tilden—History of the Progress of Chemistry.
Vallery, Radot—Pasteur (10 copies).
Walsh—Catholic Churchmen in Science (3 series).
Walsh—Cures.
Walsh—Health Through Will Power (3 copies).
Walsh—Makers of Modern Medicine (5 copies).
Walsh—Popes and Science (3 copies).
Wells—Chemical Aspects of Immunity.
Williams—History of Science—5 vols. (2 copies).
Williams—A Story of 19th Century Science.
Wilson—Great Men of Science.
Windle—The Catholic Church and its Reactions with Science (3 copies).
Woodbury—The Glass Giant of Palomar. The World's Largest Telescope.
Youmans—Pioneers of Science in America.
Zahm—Woman in Science (2 copies).

# HISTORY

## AN AUTOGRAPH LETTER FROM FR. SECCHI

REV. EDWARD C. PHILLIPS, S.J.

Among the seven or eight thousand letters constituting the autograph correspondence of Father Angelo Secchi, S.J., preserved in the Archives of the Gregorian University, Rome, there are many that would interest our readers. Father Secchi, as is well known, was for a short time (about one year) Professor of Physics at Georgetown University. There he came into close scientific relations with a number of prominent American scientists with whom he later kept up at least occasional correspondence. It is to be hoped that the Gregorian University may some day publish the more important items of Father Secchi's correspondence; it contains much of value for the history of science, especially of all that relates to Astronomy and Meteorology in Italy, and is one more notable evidence of the interest both of the Church and of the Society in the advancement of the knowledge of nature as a road to a knowledge of God, and also as a means to improve the condition of mankind. We give here a letter of "human interest" as well as of some scientific interest chosen from the extensive material indicated above.

It may be noted that when Father Secchi wrote this letter he was a Fourth Year Theologian trying, under rather heartrending circumstances, to complete his studies (which he did and passed his "Examen ad Gradum" after reaching America). His country was still in the throes of the revolution which led to the temporary exile of the Society from Rome. He had just been ordained to the priesthood (he refers to this in calling himself the "*anointed*") but his mother had not been able to be present for that event so dear to every parent's heart: and when the order to leave Rome and Italy came he was not able to visit his mother for what he considered would be a last farewell. The swift march of events, however, restored to the Pope his temporal dominion and Father Secchi was called back to Rome to take up the post of Director of the Observatory of the Roman College (now the Gregorian University) and in that post remained for almost thirty years, i.e. until his death in 1878. With this brief introduction as a setting for and an explanation of the reasons for publishing the letter we present the following translation of it made for the BULLETIN by Mr. Herbert A. Musurillo, S.J., of Woodstock College.

Translation of a letter of Fr. Angelo Secchi, S.J., dated from Stonyhurst College, England, October 19, 1848, to his mother in Italy. From the autograph preserved in the Archives on the Pontifical Gregorian University, Rome. *Carton 9, Folder V.d.*

Dearest Mother:—

In my last letter I told you of my arrival in England and likewise of my temporary residence at this College of Stonyhurst; now I would tell you of my departure for America—which is at least twice as far as I have ever been. It is six months now that I have been on this favored isle, where the disorder that is devestating the continent has not yet penetrated, though perhaps a no lesser one is being prepared, in the cholera morbus that is already manifest in many localities. Seeing that the Lord has been pleased to place us in the path of sacrifices, we ought to go forward with light hearts, assured that He will give us that help and grace whence sacrifices derive their proper advantages for our spiritual good. The date fixed for our departure from the port of Liverpool is the 23rd of this month or a couple of days later, and while you will be reading this letter I, the "anointed", shall be crossing the Atlantic Ocean bound for the United States. There I shall land at New York or at Boston (which one I don't know as yet), and from there I shall travel to Washington, the capital, and thence to the nearby College of Georgetown, where I shall be professor of physics or mathematics. It is several years now since I was asked to go there, and I would have gone, had permission been granted me; but now that there is nothing to hope for at present in Italy, Providence opens the way to America. Many Catholics and Protestants have got together to pay the traveling expenses for some of my colleagues, that they might go and labor there, and I, who was asked for by name even within these last few days, shall go along with them. The American people love liberty and learning; and I believe not only that our presence there can not destroy the former, but that it will even add to the latter. At a banquet held at Georgetown, one of the members of the Senate of that republic—who holds an important place in its government—said that "he held it for certain that the ruin of the old world would be the salvation of the new, and that the numerous emigrants going thither from Europe would bring a culmination of the happiness of the nation, and that he was convinced that our own people would bring there the culture of letters and the sciences, just as the many German and French artists, arriving every day, bring their art over with them." Note, though, that he was a Protestant, and consequently he was looking merely to the temporal welfare of the Americans. But the Bishops there clamor for us and desire to have us for the propagation of the Christian and Catholic religion, and in order to keep up the numerous missions over there. Such things are very encouraging for us, and we hope that Our Lord will make use of such unworthy instruments as we are for the spread of His glory.

If I desired to see you at least once before coming to England, you can well imagine how I would like to do so now that I am about to undertake a journey so long that it alone will last a month, and one that will thus render my return even more difficult than it was before. Well, let us both sacrifice it to the Lord, that He may give us in return those graces we need in order to remain steadfast in the midst of the turmoils that surround us.

During my stay in England my health has been excellent—or, rather, I have returned to good health—something I needed so much after the great exertions, fears and labors endured in Italy. I'm sorry that I cannot entertain you with an extended account of the things I have seen and learned in these travels of mine, some of which are very interesting; in general, however, I can say that I have completely lost the illusion I had that one can live well only in Italy. Here, of course, there are not those grand memories of antiquity, of which Italians are so proud, nor the many monuments erected in days of past opulence; instead, however, we find such life, such activity, and such wealth actually flourishing today, as certainly cannot be seen in Italy. The railroads, the steamships, the harbors crowded with vessels, the huge manufactories are things which contribute more to the well-being of a nation than temples, libraries, museums or palaces, which, incidentally are not at all lacking here. But Italy will never reach such state, because there is not in its inhabitants that spirit of application, concentration and labor, which animates English industry. The very climate with its colder and hardly ingratiating atmosphere hardens a man and causes him to find his pleasure in working, shut up in his house; while in Italy the beauty of nature invites him to rejoice and make merry. But even so, it is my belief that Italians, taken singly—even among the lower classes, are much happier than their equals in England—where the life led by so many from birth till death consists in working continually, like a machine. The English temperament, considered distant and depressing, is not found to be such if you visit them at home; and travellers of this nation may give quite an inadequate picture of their character, because of their extreme reserve with those whom they do not know and because of their continual preoccupation with business. They are (with the usual exceptions, of course) upright, law-abiding and religious, and many Protestants—who, perhaps constitute by far the greater part of the population—would put many, many Catholics to shame on the point of national virtue. Education and the practice of the Catholic religion are unrestricted here, and Catholicism is rapidly spreading, though it will probably never become the religion of the State, but it will be the better for being free of those oppressions which governments usually put upon the Church. These virtues of theirs have probably merited from heaven that temporal prosperity which they enjoy, just as St. Augustine believes it did for the ancient Romans.—And now I think I am going

to find a people even more youthful, and being an offspring of this nation, great things are told of its splendors, and after I shall have seen them I will not fail to write you of them, if, before I get there, I do not become food for the fishes.

My greetings to my sister and all the family, and when possible, recall what you wrote me in your last letter, because wherever I am it shall always be useful to me, for we have hopes that peace will be restored in the end. Believe me

Your loving son,

A. SECCHI, S.J.

Stonyhurst, Oct. 19, '48.

P. S. From now on address your letters this way:

Rev. A. Secchi<br>
Georgetown College<br>
Near Washington<br>
America United States D.C.

P. P. The word 'near' means (in Italian) presso. When you write send me all the news you can, for it is precious there, and do not imitate my own brief letters.

## PERE JEAN JOSEPH AMIOT, S.J.
(1718-1793)

JOHN J. BLANDIN, S.J.

Pere Jean Joseph Amiot, S.J., was a missioner among the Chinese and one whose name should be included in the list that embraces such illustrious names as Fathers Ricci and Schall. He was a reputable historian of Chinese culture, of their music and science, both natural and military, and a scientist in his own right. Pere Amiot was esteemed in his own day by the Chinese Emperor Kien-Long; and at the present time his works are consulted by those interested in Chinese history.

For those who may be interested in methods of high-precision weighing, in their history, or perhaps, in scientific Jesuitana, it may prove an added bit of information to know that one of the two methods of accurate weighing, most frequently mentioned in text-books, can be considered as the invention of Pere Amiot. Both methods were established for the purpose of overcoming one source of error that is

always encountered in weighing,—that due to the inequality of the length of the balance arms.

Their invention is commonly attributed to Borda and to Gauss. Concerning the latter there may or may not be contention as to the right of invention; and with reference to the former, dispute is made only to the extent that interest of an historical nature is involved.

Jean Charles Borda (1733-1799), as a matter of fact, was a student at the Jesuit College of La Fleche. He was, furthermore, a contemporary of Pere Amiot. Half the circumference of the globe, however, separated the two for the greater part of their lives. In 1850, when Borda would have been seventeen years old, Pere Amiot was sent to Peking, China, where he spent the remaining forty-three years of his life.

That Borda and Pere Amiot could have met at La Fleche is possible; but that the subject of methods of weighing had been discussed, is doubtful. Borda's subsequent career would rather indicate that physical problems of a maritime nature were far more absorbing for him than those involving weighing or the calibration of weights. Toward the end of his life, the work of Borda was definitely centered upon the establishment and calibration of national standards of measurement; and then it may have been that he popularized, improved, if not invented, the method of weighing by substitution, which M. Peclet would attribute to Pere Amiot.[1]

The contention of M. Peclet is further cited by Prof. W. H. Miller, to whom was intrusted the construction of the new Imperial Standard Pound (the old Standard having been destroyed in the burning of the House of Parliament, in 1834). In his report,[2] delivered before the Royal Society of London, Prof. Miller states: "In the comparison of weights, I at first employed the method of weighing invented by Pere Amiot, more commonly known as Borda's".[3]

It may be worth while noting that where calibration depends upon comparison with standards, the standard itself, in this instance of the Imperial Pound, was determined by comparison. The new standard, desired by the appointed Commissioners, was to be a replica of the old and not the Imperial Pound "Prescribed by Sections 3 and 5 of the Act 5th., George IV." The "prescribed Pound" should have had a weight "which bears a certain proportion to the weight of a cubic inch of water weighed in a certain manner". "Because it appears that the determination of the weight of a cubic inch of water is yet doubtful," the Commissioners deemed it wiser to construct the new Imperial Standard Pound by the use of several weights which had been most accurately compared with the former standard.

1. Cours de Physique; p. 48. (1853)
2. Transactions of the Royal Society of London;
   Vol. 146, p. 753-946; (1856),
3. Idem, p. 763.

Comparison of weights with established standards is still achieved by the method of Pere Amiot. The mathematical precision of his method will ever remain a constant. Advancement in the manufacture of weights and of balances, and in the methods of weighing, has achieved the elimination of errors from sources other than those arising from the inequality of the lengths of balance arms. That problam had been solved in the 18th. Century by Pere Amiot, or by Borda.

Loyola College,
Baltimore, Md.

## WHO FIRST WORE A WRIST WATCH?

The following is an early reference to such a manner of carrying a watch, taken from the PENSEES de Blaise Pascal. Texte de Leon Brunschvicg. Edition Lutetia; Paris. Published by Nelson. (No date on title page). (This is a free translation of PENSEE n. 5 in Section I, p. 49.)

"Those who judge of a work without fixed rules of criticism are, with regard to others, like those who possess a watch, with regard to others (who have no watch). One says: "we've been here two hours"; another replies: "It is only three quarters of an hour". I look at my watch, and I say to the first: "You must be bored"; and to the other: "Time passes very quickly for you, for we have been here an hour and a half". And I laugh at those who tell me that time hangs heavily upon me, and that I let my imagination rule my judgment; for they do not know that I judge time by my watch."

To this text of Pascal the Editor of the Pensees adds the following explanatory note.—This was an idiosyncrasy of Pascal; he "always wore a watch attached to his left wrist", and was thus able to consult it without anyone noticing it.

As Pascal lived from 1623 to 1662, and "always" wore a wristwatch, we may assume he thus wore it from about middle life, or about 1640; as it was an "idiosyncrasy" of Pascal we may surmise also that he initiated the practice at least in his own surroundings. Thus the practice is three centuries old. Is there any evidence of its being still older?

E. C. P., S.J.

# MATHEMATICS

## THE VALIDITY OF NON-EUCLIDEAN GEOMETRY

Robert B. MacDonnell, S.J.

The story is told that when the great French mathematician, Comte Joseph Louis Lagrange, late in his life appeared before the Royal Academy of Science to read a paper on the theory of parallels, he suddenly broke off his reading with the exclamation: *"Il faut que j'y songe encore,"* and refused to allow the publication of his manuscript.

The reaction of Lagrange may be said to be characteristic of the world of mathematics when faced with the problem of Euclid's parallel postulate until the 19th Century. The greatest minds had examined Euclid's work, had admired its logical perfection, but it was agreed that there was one weak link—the parallel postulate, i.e., that when a straight line meets two straight lines so as to make the two interior angles on the same side of the transversal less than two right angles, then these two straight lines when continually produced will meet on that side on which the angles are less than two right angles.

Note: Other propositions equivalent to Euclid's postulate are given on pages 135 and 136.

Even in the time of Euclid, and from that time down through the centuries, the Greek, Arabian and European mathematicians attempted to prove this postulate and thus vindicate the Alexandrian Founder of Geometry. Most of the early "proofs" were of no great scientific value since they had inherent weaknesses, and although some were quite plausible as will be shown later, they failed to save the Fifth Postulate from later attacks. The first great advance was made by Father Girolamo Saccheri, S.J., who unconsciously laid the foundations of non-Euclidean geometry. His life and work were outlined by Rev. Henry A. Boyle, S.J., in the December, 1939, issue of the Bulletin. In the present paper an attempt will be made to trace some of the work done in non-Euclidean geometry after the time of Father Saccheri.

Perhaps the greatest obstacle to one beginning the study of non-Euclidean geometry is of a psychological nature. The imagination is dominated by and spontaneously follows Euclidean geometry, and for this reason the student, when considering the consequences of deny-

ing the Fifth Postulate, sometimes comes to the conclusion that he is studying a purely imaginary geometry which has no possibility of objective reality. In such study it is necessary to follow mathematical concepts rather than sense images. Otherwise there is great danger of falling into such errors as the following "proofs" of the Fifth Postulate.

*Some Erroneous "Proofs" of Euclid's Postulate*

1. Ptolemy (2nd Cent. A.D.) attempted to prove the often assailed postulate in the following manner.

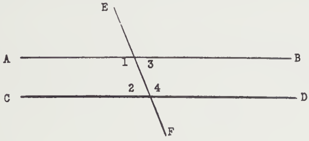


Figure 1

Figure 1.—Assume as parallel lines (i.e. lines in the same plane which do not meet) AB and CD. They are cut by the transversal EF, making the angles 1, 2, 3, 4. Then the sum of angles 1 and 2 will be equal to, less than, or greater than two right angles. Whichever one of these alternatives is true of angles 1 and 2 will be also true of angles 3 and 4.

If angles 1 and 2 be less than two right angles, the angles 3 and 4 will also be less than two right angles, so that the sum of all four angles will be less than four right angles—an absurd conclusion.

By similar argument, angles 1 and 2 cannot be greater than two right angles.

Therefore the sum of angles 1 and 2 must be equal to two right angles. From this Euclid's postulate follows directly.

Ptolemy actually begged the question when he assumed that the sum of angles 1 and 2 equals the sum of angles 3 and 4. This assumption is true only if Euclid's postulate holds.

2. Proclus (5th Cent. A.D.) attempted to prove Euclid's postulate by showing that a straight line which meets one of two parallels must also meet the other.


Figure 2

Figure 2. Let the transversal EF cut the straight line AB which has been drawn parallel to CD. The distance between the intersect-

ing lines AB and EF becomes indefinitely great if these lines are extended sufficiently. Since the distance between AB and CD is finite, EF must therefore eventually intersect CD. Euclid's postulate then follows.

Here Proclus is also guilty of the petitio principii, assuming that the distance between parallel lines is bounded. This assumption is verified in Euclidean geometry, but does not hold in the system of Lobatschewsky where the parallel postulate is rejected.

3. Bernhard Friedrich Thibaut (1775-1832) developed another interesting but erroneous "proof". During the 18th and 19th centuries attempts were made to prove that the sum of the angles of a triangle is equal to two right angles. A proof of this theorem without the assumption of Euclid's postulate would be an indirect proof of the latter. It is along these lines that Thibaut proceeded.

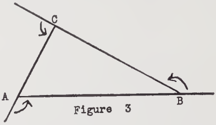

Figure 3

Figure 3. Given the triangle ABC. Let someone walk about the periphery starting from the point A. He walks to the point B, turns through the exterior angle B, proceeds to the point C and turns through the exterior angle there, then returns directly to the starting point A, and turns through the exterior angle A. He now finds that he has completed a revolution. Therefore, the sum of the exterior angles of the triangle is four right angles, and the sum of the interior angles must be two right angles.

This proof seems quite convincing until one begins to doubt that successive rotation about several points is equivalent to rotation about one fixed point. To use the terminology of Euclidean geometry, this assumption presupposes that when a transversal cuts parallel lines the corresponding angles are equal, an assumption which is of course inadmissable in any attempt to prove Euclid's postulate.

### *Equivalent Propositions*

These are but a few of the many "proofs" which are based upon propositions equivalent to Euclid's postulate, i.e., propositions which can be derived from the Fifth Postulate and can likewise lead to it. Some of these equivalent propositions are the following:

1. Two straight lines parallel to a third straight line are parallel to each other.

2. Through a point outside a straight line one, and only one, straight line may be drawn parallel to the first.

3. Two parallel straight lines are equidistant.

4. If a straight line intersects one of two parallels, it must also intersect the other.

5. The locus of points equidistant from a straight line is a straight line.

6. The sum of the angles of a triangle is equal to two right angles.

Again it may be noted that the mind trained merely in Euclidean geometry would unhesitatingly affirm the truth of these propositions. Perhaps the psychologist can explain why such propositions seem to possess intuitive truth, while upon analysis they are utterly unprovable, and may even be rejected without leading to contradictions. The final rejection of the Fifth Postulate has had startling epistemological effects. The denial of this postulate which for centuries had been considered indubitably true led some to doubt whether there were any fundamental principles which were universally true.

The belief that a proof of the Fifth Postulate would sometime be found has passed through several successive stages. For nearly two thousand years after Euclid, mathematicians were convinced that there must be a proof, and spent great effort in attempts to give a strict demonstration of it. Later the great number of unsuccessful attempts led to a belief that the postulate was true, but utterly unprovable. Finally with the development of non-Euclidean geometry, it has been shown that it is impossible to prove the Fifth Postulate of Euclid, and that the postulate itself is not necessarily true.

### *Impossibility of Proving Euclid's Postulate*

One of the greatest paradoxes in the history of mathematics is the fact that centuries of effort to prove the Fifth Postulate led finally to a proof that the postulate is not necessarily true. In 1830, Lobatschewsky showed that it is completely independent of the other postulates in the system of Euclidean geometry, rather than a necessary consequence of them as had been believed. When the non-Euclidian geometries of Lobatschewsky and Riemann became wide-spread and generally accepted, further proofs were presented to the same effect. The proof developed by Felix Klein about 1870 is fairly simple.

To every symbolic proposition in non-Euclidean geometry Klein gave a Euclidean meaning. In this way Euclidean geometry became a particular case of a more general non-Euclidean geometry, while the latter was applicable to either Euclidean or non-Euclidean space frames. Thus the straight line, or Euclidean shortest distance between two points, was taken as a particular geodesic (the shortest distance between two points on a curved surface), while all of the properties of angles and triangles formed by straight lines had cor-

responding properties in geodesic angles and geodesic triangles. When all of the propositions and properties of non-Euclidean geometry were translated so as to have a corresponding Euclidean sense, Klein's conclusion followed that any contradiction in non-Euclidean geometry would lead to a corresponding contradiction in Euclidean geometry. The freedom from contradiction in Euclidean geometry thus serves as justification for non-Euclidean geometry, and banishes forever any hope of proving the postulate whose denial is the foundation-stone of these geometries.

Note: A more precise but perhaps more difficult summary of Klein's argument is the following. If we consider a plane and a certain other fairly simple surface (the pseudosphere), we may frame a set of definitions for the straight line, angle, etc., in the plane, and these definitions will at the same time determine a type of line, a measure of angle, etc., on the second surface. Now a certain set of postulates made with respect to all these elements has interesting conclusions. With regard to the plane, the conclusions are precisely those of Lobatschewskian geometry; but with regard to the second surface they are identical with conclusions which follow simply from Euclidean geometry when applied to that surface. Hence, if those postulates and definitions were logically inconsistent, Euclidean geometry as applied to that surface, and therefore Euclidean geometry itself would be inconsistent.

*Development of Non-Euclidean Geometry*

Almost a century elapsed after the publication of Father Saccheri's "Euclides ab omni naevo vindicatus" in 1733 before geometers made any great advance beyond the work of the Jesuit mathematician. The noted German, Carl Friedrich Gauss, seems to be the first to attempt a geometry independent of the Fifth Postulate. Like his Jesuit predecessor, Gauss was attempting to prove the postulate by finding contradictions in the assumption that it was false. Although responsible for the first non-Euclidean geometry, Gauss did not finish his work, and thus did not leave a complete geometry. Then came the Astral Geometry of Ferdinand Karl Schweikart, further advanced than that of Gauss, but not published. It is worthy of note that the conclusions of both Gauss and Schweikart may be obtained from Father Saccheri's hypothesis of the acute angle, which was outlined in the December, 1939, issue of the Bulletin.

The greatest single departure from Euclid was made by the Russian, Nicolai Lobatschewsky, founder of the system of geometry which bears his name. Lobatschewsky discarded the Euclidean definition of parallels as lines in the same plane which do not meet, and chose as his new definition the following: With respect to a given straight line, all others in the same plane may be divided into two classes, those which meet the given line and those which do not meet it; a line which divides the two classes is called parallel to the given straight line.

This definition may become clear from the following:

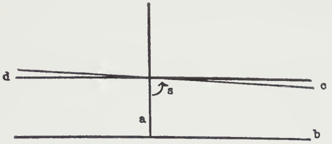


Figure 4

Figure 4. Draw *a* perpendicular to *b*. Draw *c* so that it will not meet *b*, then diminish angle *s* so that *c* will meet *b* when both are extended. Draw *d* making the same angle *s* on the other side of *a*. Then all lines in the pencil between *c* and *d* will not intersect *b*, and the lines *c* and *d* become the boundaries between the intersecting and non-intersecting lines. These lines *c* and *d* are the Lobatschewskian parallels to *b*.

According to Euclid, *c* and *d* would be identical since in a plane only one line may be drawn through a point parallel to a given line. Even in the Lobatschewskian case, *c* and *d* cannot be distinguished by the eye as two distinct lines since both are very nearly perpendicular to *a*. For convenience of representation we have greatly exaggerated the angle between *c* and *d*.

The angle *s* is called by Lobatschewsky the angle of parallelism for the length *a*, with symbolic representation $\Pi\ (a)$. Parallels may be drawn at any point along *a*, and it is found that the angle of parallelism diminishes for larger values of *a*, and is 90° only when *a* vanishes. In Lobatschewskian geometry, therefore, $\Pi\ (a)$ is a function of *a*, whereas in Euclidean geometry it is always equal to 90°.

To develop his trigonometric formulae, Lobatschewsky assumes a circle which expands indefinitely. When the circle reaches the state where the convergence of radii drawn inward from the circumference corresponds to the condition of parallelism, the radii no longer intersect. Such a circle is called a boundary-line or horocycle, while the sphere formed by such circles is called a boundary surface or horosphere. The geometry of the horocycle and horosphere corresponds respectively to that of the Euclidean line and plane.

For a plane triangle ABC, with the sides a, b, c, and with $\Pi$ (a), $\Pi$ (b) and $\Pi$ (c) as the corresponding angles of parallelism, Lobatschewsky obtained as his fundamental formula:

$$\cos A \cdot \cos \Pi\ (b) \cdot \cos \Pi\ (c) + \frac{\sin \Pi\ (b) \cdot \sin \Pi\ (c)}{\sin \Pi\ (a)} = 1.$$

From this it is evident that the Lobatschewskian system departs radically from that of Euclid, built as it is upon the new notion of parallelism. That the results of the two systems are not greatly dif-

ferent will be clear from the simple case of the right triangle. For this case Lobatschewsky's equation becomes

$$\sinh \frac{a}{k} = \sinh \frac{c}{k} . \sin A$$

But since $\sin (ix) = i \sinh x$

$$\sin \frac{a}{k} = \sin \frac{c}{k} . \sin A$$

In these equations k represents a constant distance. Now if it can be shown that k is extremely large compared to a and c, this last formula will clearly approximate

$$a = c \sin A$$

the ordinary formula of Euclidean trigonometry, indicating the difficulty of verifying either Euclidean or Lobatschewskian as the truly objective geometry of the universe. Supposing Lobatschewskian geometry to be true, we may obtain as a value of k a distance more than a million times the radius of the earth's orbit. This value is sufficiently great to indicate that the difference between results according to the two geometries is most minute—so small, in fact, that in the belief of most mathematicians observations of the universe will never determine which is objectively verified.

A similar defence might be made of the validity of Riemannian geometry. Riemann discarded Euclid's postulate, and chose Father Saccheri's hypothesis of the obtuse angle as the foundation of his system.

Thus we see that just as a priorism cannot determine whether the true geometry of the universe is Euclidean or Lobatschewskian or Riemannian, since all three systems are equally logical and consistent, so also there is little hope of experimental verification. It may remain as one of the enigmas of science.

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# PHYSICS

## FREQUENCY MODULATION IN RADIO TRANSMISSION

LAURENCE C. LANGGUTH, S.J.

During the past summer an entirely new type of radio broadcasting station was completed and put into operation for test broadcasts from a high hill in the Town of Paxton, in central Massachusetts, seven miles west of the city of Worcester. It is Station W1XOJ, owned and operated by Mr. John Shepard's Yankee Network, operators of Station WNAC in Boston. It employs the new system of frequency modulation developed within the past few years by Major Edwin H. Armstrong, Columbia University Professor and already a well-known name in radio. The first commercial station so constructed, it suggests the timeliness of a paper presenting briefly the history of frequency modulation, the manner of its operation, and the claims made for it and the results achieved over the conventional mode of amplitude modulation.

About twenty-five years ago, when the art of radio broadcasting was still in its infancy, Major Armstrong became interested in the elimination of static and other unwanted disturbances. After several years work he gave up because, as he says, he "ran out of ideas." The problem appeared insoluble. Ten years later, about 1925, he commenced an exploration of the possibilities of frequency modulation, which before that time had been found completely unsatisfactory. He has proved that when properly handled it is an efficient method of radio communication, almost entirely free of atmospheric and instrumental disturbances.

A comparison with amplitude modulation, now universally employed in radio broadcasting, will help to clarify the notion of frequency modulation. In amplitude modulation it is the *amplitude* of the radio frequency carrier wave emitted by a station which is made to vary in accord with the audio frequency signal to be transmitted; the *frequency* of this carrier wave remains substantially unchanged, fixed within narrow limits at the frequency by which the station is designated. In amplitude modulation, it is the *quantity of energy* radiated from the station which varies, whereas in frequency modulation the quantity radiated remains unchanged, and it is the *carrier*

*frequency* itself which varies or "wobbles" between fairly wide limits in accord with the audio signal to be transmitted.

Amplitude modulation may be accomplished in several different ways, as by varying the plate voltage impressed on the oscillator tube, or by putting the signal voltage on the control grid or the suppressor grid of a modulator tube. We must remember however, that there is always associated with it a certain measure of frequency modulation, since the addition of an audio frequency to the radio frequency carrier wave produces beat frequencies in the radio range, extending as far above and below the nominal value of the carrier wave as the highest audio frequency to be transmitted. Thus if a station transmits on 1000 kilocycles an audio tone of 5 kilocycles, the beat frequencies are the sum and difference of these, or 995 and 1005 kilocycles, and the station requires a bandwidth of ten kilocycles in which to operate. Commercial stations are at the present time alotted such a bandwidth, twice the frequency of the highest tone they are permitted to transmit.

It was in an effort to eliminate this requirement of a bandwidth twice the audio tone and so accomodate a greater number of stations in a given region of the radio spectrum, that frequency modulation was first tried in the early days of radio. But the experiment and theory both proved that the hope was vain, that a frequency-modulated wave required a bandwidth at least twice the modulating frequency, and worse, that it inherently distorted the program transmitted. However, the frequency modulation then employed extended over only a narrow band of frequencies, comparable with that associated with the amplitude modulation of today, and such as might be obtained by incorporating a condenser microphone in the oscillatory circuit. Major Armstrong's contribution consists in the use of wide-band frequency modulation, involving a bandwidth of one hundred and twenty kilocycles instead of ten. He has found that static and other unwanted electromagnetic disturbances consist of large fluctuations in amplitude over a comparatively narrow frequency range; so by designing a broadcast system which is relatively independent of fluctuations in amplitude, and whose signal is carried by wide fluctuations in frequency, he has almost perfectly excluded noise from radio transmission.

In the design of a transmitter to produce such a frequency-modulated wave, the requirement of exceptionally broad bandwidth pointed to the selection of an uncongested region of the radio spectrum, prefreably in the ultra-high frequencies. That selected was about 40,000 kilocycles, or 40 megacycles. The carrier wave is not generated at this very high frequency however; the original oscillator is tuned much lower, its output is modulated first in phase, and then transformed into frequency modulation over only a narrow band, after which the carrier frequency and the bandwidth are both multiplied to

the desired figure. Major Armstrong describes[1] his transmitter somewhat as follows.

The carrier wave originates in a crystal-controlled oscillator which generates a 200 kilocycle wave. The output of this oscillator divides along two parallel paths, one of which leads to an amplifier and the other to a so-called "balanced modulator" (Fig. 1). The

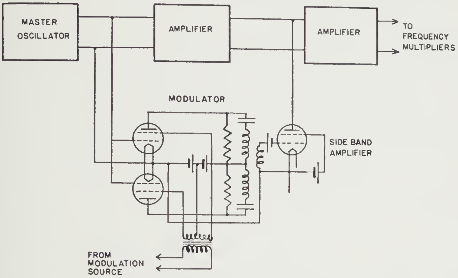


*Figure 1*

The "Balanced Modulator," for the production of the frequency-modulated signal.

modulator consists of two tubes in push-pull; upon their first grids is impressed the voltage from the oscillator, while the second grids are connected to the modulation source, one to each end of the secondary of a coupling transformer whose center tap goes to the cathode, as in the conventional push-pull arrangement. The signal voltages impressed upon these grids are therefore always one hundred and eighty degrees out of phase with respect to each other, and the effect of the whole balanced modulator is to alternately advance and retard the phase of the oscillator voltage passing through it by an amount which is directly proportional to the amplitude of the modulating voltage and inversely proportional to its frequency. When this phase-modulated wave, after passing through a side-band amplifier, is combined with the amplified but unmodulated output of the oscillator in the opposite path, the two interfere to produce a frequency-modulated wave, whose frequency shift extends over only a narrow band.

Now in the balanced modulator the largest phase shift allowable for linear response and hence for good quality reproduction is 30 degrees, which because of the inverse relationship corresponds to

[1]Armstrong, Edwin H., "A Method of Reducing Disturbances in Radio Signalling by a System of Frequency Modulation," Proc. I. R. E. Vol. 24, p. 689, (May 1936).

the lowest frequency. On the same circuit basis an audio note of ten thousand cycles will produce a phase shift of but 0.09 degrees. This would be quite insufficient at the output of the transmitter, where the minimum allowable phase shift for full modulation is 45 degrees. This increase in phase angle, and hence in frequency band-width, is accomplished by frequency doublers and triplers, whereby also the original frequency of 200 kilocycles is built up to the 40 megacycles or so now in use.

Roder of General Electric aptly describes[2] the resulting frequency-modulated wave. "The amount of the frequency shift is made proportional to the amplitude of the audio signal; the frequency of the frequency shift is equal to the audio frequency." And he suggests a simple numerical example. Suppose that the maximum frequency shift for maximum audio amplitude is 100 kilocycles, which would then correspond to 100 per cent modulation in amplitude modulation. A one thousand cycle signal, whose amplitude is 50 per cent of maximum, will require a frequency shift of 50 kilocycles at a rate of one thousand times each second.

Special receivers will of course be required to receive the frequency-modulated wave. Roder describes one consisting of radio-frequency, mixer, and intermediate-frequency stages, second detector, and audio output stages, similar to the conventional super-heterodyne circuit of present day receivers (which also was invented by Major Armstrong.) However, between the last intermediate-frequency stage and the second detector we have a limiter, followed by a frequency-amplitude converter. The limiter is a kind of automatic volume control, a special amplifier designed to yield an intermediate-frequency output whose amplitude is fixed at a constant value regardless of the input amplitude (provided of course that the latter be above a certain minimum threshold value.) Obviously the function of the limiter is to render the receiver insentitive to fluctuations in amplitude, which is a great step forward in the elimination of noise.

The frequency-amplitude converter is the only really unique thing about the whole receiver. Its function is to change the frequency-modulated wave into an amplitude-modulated one, which may be detected in the usual way. In principle it can be represented by a resonant circuit so tuned that the intermediate frequency fed to it through the limiter falls upon the steep side of its resonance curve, at the steepest point (Fig. 2). Then any increase in frequency will increase the response of the circuit, and a decrease in frequency will decrease the response of the circuit, and the result will be an amplitude-modulated intermediate-frequency output. Values may be so chosen that the circuit shall be relatively insensitive to small frequency changes, and the limiter has already made it insensitive to

[2]Roder, Hans, "Effects of Tuned Circuits upon a Frequency Modulated Signal," Proc. I.R.E. Vol. 25, p. 1617 (Dec. 1937).

amplitude changes, so we have a receiver which effectively discriminates against noise while passing its intended signal undisturbed.

The advantages claimed for the new system are several. One

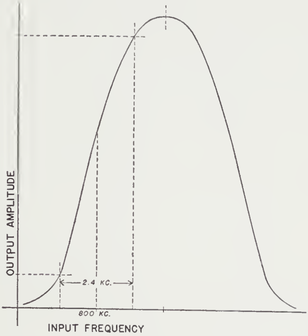


*Figure 2*

Resonance curve to illustrate the action of the frequency-amplitude converter. It is assumed that the 40 mgc. carrier has been heteradyned down to 800 kc. and that the bandwidth of 120 kc. has correspondingly shrunken to 2.4 kc.

of the less spectacular, but an extremely important one, is inherent in frequency modulation. It is the high level of field strength maintained by the station with relatively low power consumption. We have already pointed out that in amplitude modulation it is the power or energy radiated by the station which is caused to fluctuate by the audio modulation. If the carrier wave be 100 per cent modulated, then the station is alternately radiating maximum and zero energy, and its carrier level corresponds not to its peak energy but to one-quarter of that peak energy[3]. In frequency modulation, on the other hand, no fluctuation in power output ever occurs. The station is always radiating at maximum; hence its carrier level corresponds to

[3]This is so because in wave motion energy varies not as the first power but as the square of the amplitude. Suppose a station whose peak amplitude is 100 units operates at 100 per cent modulation.

Then $A_{min.} = 0$ and $A_{max.} = 100$

$$A_{av.} = \frac{0 + 100}{2} = 50 = \tfrac{1}{2} A_{max.}$$

Energy $\propto A^2$

$E_{av.} \propto A_{av.}^2 = (\tfrac{1}{2} A_{max.})^2 = \tfrac{1}{4} A_{max.}$ or $\tfrac{1}{4}$ peak.

peak and not to one-quarter peak energy. And the field strength of a frequency-modulated station is four times as great as that of an amplitude-modulated station of equal power rating.

Moreover, amplitude-modulated stations make most efficient use of their field strength when they operate at 100 per cent modulation, but in practice they cannot so transmit. A reserve of power has to be kept for over loads, for extremely loud passages of music or speech, which otherwise would make dangerous demands upon the power supply equipment and cause arcing and breakdown. As a matter of fact, transmitters are continuously monitored manually, the controller advancing the gain to bring the signal above the noise level when the sound level is naturally low, and retarding the gain to keep within safe limits when the sound level is high. This of course causes dynamic distortion of the reproduction, but in amplitude modulation it is a necessary evil.

Not so in frequency modulation. Since abnormally loud audio tones simply cause more vigorous frequency swings, no unusual demands are made on the power supply, and due to the low noise level the gain need never be advanced in the more quiet portions of the program. Hence the intelligence transmitted is a much more faithful reproduction of that impressed upon the microphone in the studio, and the need for supervision is practically eliminated.

An apparent disadvantage of the new system is the broad spread of frequencies required in transmission, thus unduly limiting the number of commercial broadcasting stations that might be accomodated in a band of given width. That the difficulty is only apparent will be evident from the following consideration. If we take the octave as the fundamental interval, as it appears we are justified in doing in any discussion of spectra, radio or otherwise, then the present broadcast band extends roughly over an octave and a half, from 500 to 1500 kilocycles. Likewise, the ultrahigh frequencies in which frequency modulation has thus far been found to be practicable extend at least over an octave and a half, from the 40 megacycles or thereabouts of Armstrong's and Shepard's transmitters to 80 megacycles and on to 130 megacycles[4]. Let us limit our consideration to a single octave, for simplicity. Allowing a ten kilocycle bandwidth in the broadcast band, only fifty stations can be accomodated in the octave from 500 to 1000 kilocycles. In one octave of the ultrahigh frequencies however, from 40 to 80 megacycles, three hundred and thirty-three stations can be accomodated despite the requirement of a bandwidth of 120 kilocycles. It is evident then that the frequency-modulated station using short waves requires a *proportionately* nar-

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[4]A low-power frequency-modulated transmitter, working at 132.26 megacycles, is now being operated by the Yankee Network in Boston to relay the program material from the studios of Station WNAC to the transmitter at Paxton.

rower band than the amplitude-modulated stations of the present broadcast frequency.

Moreover, frequency-modulated stations operating on identical frequencies may be built geographically closer together than is possible with the present amplitude-modulated systems. This is partly due to the wavelength employed, since these ultra short waves are lost skyward, do not curve with the curvature of the earth, and their effective radius of influence and disturbance is considerably less than that of the longer waves. But it is due principally to the following technical consideration. A receiver intended for amplitude-modulated signals, precisely because it is made sensitive to changes in amplitude, requires a considerable difference in the intensity of radiation from two stations of identical frequency. In practice, the signal rejected must be less than one percent of the signal desired, in order that the reception be satisfactory. In other words, the station desired must have a field strength at the receiver more than one hundred times as great as the station rejected. In frequency modulation however, the required difference is only fifty percent, or the station desired need have a field strength only twice as great (not one hundred times) as the station rejected. The interfering station in the extreme case will of course produce a fifty per cent voltage variation in the antenna, but the receiver has been made sensitive to such variations, and they will not produce audible interference.

Major Armstrong designed and constructed several frequency-modulated transmitters to test his method in the field. The first of these was the RCA short wave television transmitter, then under construction atop the Empire State Building, which he was allowed to adapt to his purpose. Later a small transmitter of about 100 watts was constructed at the home of a radio amateur in Yonkers, and finally came Armstrong's own 40 kilowatt transmitter in Alpine, N. J. The two latter continue in operation, and it was demonstrations with them that moved Mr. Shepard to build the new station at Paxton, Mass.

The most striking feature of the new system in demonstration is its remarkably quiet operation. The ratio of useful signal to noise is in most cases about 1000 to 1, which means that the usual background noises—those originating within the system itself, such as thermal noises in the tubes, as well as those picked up from without, such as atmospheric static and lightning—are in general so low as to be completely inaudible. The ignition systems of some automobiles give trouble, but only when they are in the immediate vicinity of the receiver; and this difficulty is being eliminated at its source by the automobile manufacturers, who must protect from disturbance the radios they install in their cars. Severe lightning flashes cause audible noise, but again only when they are in the immediate vicinity, which is never for very long. It is a striking thing that the small 100 watt station in Yonkers can be better heard fifty miles

down Long Island when static and storm conditions are severe than can the huge 50,000 watt transmitter of WEAF only half as far away.

A second admirable quality is the high fidelity of the system. The small relay transmitter operated in Boston by the Yankee Network has been tested from microphone terminals to loudspeaker terminals, and has been found to have a frequency response flat within two decibels from 30 to 17,000 cycles, and to be down only seven decibels at 30,000 cycles. That comes close to perfection in the transmission of audible sounds. Such performance means of course that existing studio equipment in the audio range, such as microphones and preamplifiers, will be antiquated as incapable of driving the transmission system to its complete efficiency. Even with these present limitations however, the new type transmitter can produce startlingly realistic effects.

Mr. John Shepard, who may perhaps be pardoned for being a little enthusiastic, has been saying that the new system, as soon as it becomes well enough known to the public, will replace the old as rapidly as orthophonic recording replaced the old mechanical method. And it is said that within a year after orthophonic phonographs were introduced the old styles were obsolete. Though that prediction may be a little extreme, still it is true that Shepard's station has already commenced regular daily broadcasts from eight o'clock in the morning to midnight, about a dozen other stations have been licensed by the Federal Radio Commission, General Electric's receivers for the frequency-modulated waves have been on sale for some months in the New York area, and at least two other manufacturers, Stromberg-Carlson and Zenith, have receivers in production. So it seems that despite the enormous investment in amplitude-modulated equipment, both transmitters and receivers, frequency modulation will prove to be of more than passing interest in the world of radio.

**References**


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- Vol. 23, pp. 517—540 (May 1935)—Chaffee
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- Vol. 24, pp. 898—913 (June 1936)—Crosby
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- Vol. 25, No. 12, p. 1617 (1937)—Roder

Electronics

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Technology Review

- Vol. 41, No. 5, p. 200 (Mar. 1939)
- Vol. 41, No. 6, p. 257 (Apr. 1939)

## LABORATORY SUGGESTION

Sometimes in the Physics Laboratory, especially for experiments carried on in the darkened "Light Room" with no windows facing a distant horizon, it is difficult to make sure that the telescope and the collimator of the spectrometer are focused for parallel rays. The following method (Schuster's), included as an Appendix, page 654, to Worsnop and Flint's Advanced Practical Physics for Students (Methuen and Company, London, 1931; Third Edition), will be found quite helpful in such cases.

Illuminate the slit of the collimator with monochromatic (yellow) light, without paying any previous attention to the focussing. Place the prism approximately in the position of minimum deviation. Turn the prism slightly away from this position, bringing its refraction edge *towards the telescope*. This will make the angle of deviation greater than the minimum: rotate the telescope so that the refracted image of the slit is in the center of the telescope field, and focus the telescope sharply on the image. Next rotate the prism slightly away from the telescope until the rays pass through their minimum deviation and come back again to the center of the telescope field; if the collimator is already focussed for the emission of parallel rays the image will remain sharply in focus; if not, then carefully focus the image by moving *the collimator slit* in or outwards as need be. Turn the prism again so that it is in its previous position and refocus, if necessary, with the telescope eyepiece. Two or three repetitions of this process will produce the required focussing of both collimator and telescope for parallel rays. Be careful always to do the focussing with the tube (telescope or collimator) *towards which* the refracting edge of the prism has been last rotated; otherwise the image will become more and more indistinct or out of focus on each alternate rotation.

E. C. P., S.J.

## LABORATORY DEMONSTRATIONS

REV. JOHN S. O'CONOR, S.J.

The following equipment has been found useful in modernizing certain demonstration and laboratory experiments:

The General Electric high intensity mercury lamp type H4 100W. This lamp provides a source of 6000 candles per square inch with a beam candle power of about 375.

A small fused quartz tube (one half inch by one sixteenth) is mounted in an outer bulb one and a quarter by five and five eights inches. The lamp may be burned in any position and need not be

tipped for starting. A special transformer is required. The lamp, socket and transformer list for $15.00,—subject to regular Mazda lamp contract discount.

With this lamp and the ordinary carbon disulfide prism the Hg. line spectrum can be projected so as to be clearly seen by all in a brilliantly illuminated class-room or in *daylight.*

Observed with the spectrometer it is most interesting to watch the formation of the continuous spectrum as a background to the bright lines, as the pressure in the capillary builds up from that existing at room temperature to a maximum of 8 or 10 atmospheres as the arc reaches normal operating temperature.

Using the same lamp and two pairs of "Polaroid" sun glasses the focused image of the Hg. capillary on a screen may be brought to what appears to be complete extinction by the crossed polaroid glasses. This is even *more effective* in a well lighted room as the actual extinction is only about 70% of total, but the residual light transmitted can not be seen in the presence of daylight.

The two pairs of sun glasses may be used at other times for their normal purpose at a total saving of $6.00.

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Lucite, the relatively new Du Pont transparent Plastic, featured in many exhibits at the World's Fair, which has an index of refraction of between 1.50 and 1.52 lends itself most conveniently to the demonstration of the phenomenon of total internal reflection.

Secured in rods of almost any desired diameter it may be bent into the required shapes by heating in water (or oil) to a temperature of about 180° F.

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The International Telephone Development Co. (Rectifier Division of the I. T. & T.), 67 Broad St., N. Y. C., are now producing commercially Selenium Rectifier Assemblies which seem to be a considerable improvement on the commonly known copper oxide rectifier. The efficiency of the Selenium type can be made as high as 85%. Current of 20 amperes are easily obtained and the units are recommended as supply sources for high voltage testing, so are not limited in that respect. Practically unlimted life is claimed for this rectifier.

# MANILA OBSERVATORY

**New seismographs.**—A secondary station was established at Ambulong, at the northeast corner of Lake Taal, in 1912 as a check on Taal volcano. In February, 1939, the old seismographs were dismounted and replaced by a 200-kg Wiechert Inverted pendulum.

Tagaytay Ridge, 2100 feet in height, borders the north side of Lake Taal and is being developed as a resort. The Manila Hotel has recently constructed a small hotel and cottages on the Ridge and also erected a small observatory. This has been equipped with meteorological apparatus and a 200-kg Wiechert Inverted Pendulum seismograph. This location is northwest of the volcano and the two seismographs, the movements of which can be speeded up if necessary, are expected to furnish material for the accurate location of earthquakes originating under or near the volcano.

New anemometer.—A Dynes anemometer, purchased by government appropriation, was put into operation on February 1, 1939. Hoisting the steel mast to the top of the east tower was a two day operation. This anemometer gives a beautiful record of wind direction and velocity. The older instruments in the observatory give only integrated values of velocity whereas the Dynes gives a continuous record from which the high velocities in gusts can be heard. The recording pens have been greatly improved by Father Doucette and he has also calibrated the instrument in spite of discouraging comments by the Director of the Hong Kong Observatory.

Personnel. Mr. Pablo Guzman-Rivas, 1st Year Regent, was assigned to the Observatory in June, 1939, and devotes his time to the Astronomical section. He also teaches Astronomy in the Ateneo de Manila.

Father Leo G. Welch arrived in Manila on October 30th, 1939, and will take the position left vacant by Father Nuttall. Father Welsh graduated from Massachusetts Institute of Technology in June and attended the sessions of the International Geophysical Union in Washington in September, representing the Manila Observatory.

# NEWS ITEMS

## NATIONAL MEETING OF JESUIT SCIENTISTS

The fifth annual meeting of the National Association of Jesuit Scientists was held on December 28, 1939, at the Knights of Columbus Hall, Columbus, Ohio. The following provinces sent representatives:

Chicago Province, Missouri Province, New Orleans Province, New England Province, Maryland—New York Province, Northern and Southern sections.

The presiding officer was Rev. Richard B. Schmitt, S.J., Loyola College, Baltimore, Maryland, assisted by the Secretary, Rev. Emeran Kolkmeyer, S.J., Canisius College, Buffalo, New York.

The topics for discussion included:

*Report on the Science Conventions of the various provinces during the year.*

*Report on the Research Work in our colleges and universities.*

*Announcement of the National Science Convention as part of the Quadricentennial Celebration of the Society.*

*The History of Science in the American Assistancy; Science and Philosophy.*

The Chairman read a letter from the National Secretary of Education, Rev. Edward B. Rooney, S.J., in which he stated that all the Very Reverend Fathers Provincal had given their approval of a National Science Convention. The most convenient date suggested was September 4-5 and 6th, 1940. This is the week before the National meeting of the American Chemical Society to be held at Detroit, Mich.

The place of the convention will be announced as soon as arrangements are made with the proper authorities. More details of this national convention will be published in the May issue of the Bulletin.

Copies of the minutes of this meeting were mailed to the Reverend Fathers Provincal, and to the Very Reverend Rectors of the Colleges and Universities in the United States, through the office of the National Secretary of Jesuit Education. At the election of officers, Father Schmitt and Father Kolkmeyer were chosen as president and secretary for the National Meeting.

## GEORGETOWN COLLEGE OBSERVATORY

### Astronomy Department

Rev. Paul A. McNally, Director of Georgetown College Observatory, recently published the results of his work with the United States Solar Eclipse Expedition of 1937 to Canton Island. This technical monagraph is an excellent interpretation of the data of the scientific observations made by the expedition on the intensity, extent and shape of the corona of the sun.

In the article are complete details of the instruments used and the materials necessary for obtaining the excellent photographs of the eclipse. There are two diagrams which show the intensity graphs of the corona and the sunspot cycle. Then too, there is a photograph of the 1937 corona showing the maximum sunspot shape. We take this occasion to congratulate the author on this problem of research.

In the Astronomical Journal, number 1114 is a list of the occultations of stars by the moon as observed at Georgetown College Observatory during 1938. The reductions were made by Thomas D. Barry, S.J. of Weston College; and numbers 1 to 29 were duplicated by John A. Weber, S.J. of Woodstock College.

Anyone wishing to have reprints may obtain them from the Georgetown College Observatory.

## GEORGETOWN COLLEGE. Seismology Department

Rev. Frederick W. Sohon reported that the recent earthquake in Turkey was as intense as any recorded by the University Seismic Observatory. The tremors lasted approximately four and one-half hours. Due to the intensity of the quake, the record was so confused that the distance could not be accurately approximated.

## LOYOLA COLLEGE, Baltimore, Md., Chemistry Department

On Friday, December 15, Rev. Richard B. Schmitt, Professor of Chemistry, gave a lecture at the Johns Hopkins University to the Maryland section of the American Chemical Society. The lecture consisted of a discussion of the recent progress in Micro-chemistry, in organic and inorganic fields. The lecture was illustrated with slides and kodachromes; and some new apparatus was shown.

Father Schmitt also lectured to the Washington Section of the American Chemical Society at the University of Maryland, College Park, on December 7th. The subject was: "Recent Development in Micro Organic Analysis."

On Wednesday, December 6th another lecture was given by the same speaker at City College. The subject was: "The Story of Sugar". In the audience were 1800 students.

On January 17th, Father Schmitt gave an illustrated lecture to

the Faculty and students of the Chemistry Department of Georgetown University on the subject: "Recent Developments of Micro Chemistry."

At the December meeting of the Loyola Chemists Club, Dr. David I. Macht, M.D., gave an illustrated lecture on the subject: "Snake Venoms". This lecture was most interesting and instructive.

On Tuesday, February 13th, Dr. John C. Hubbard, Professor of Physics of The Johns Hopkins University, lectured to the members of the Loyola Chemists' Club on the subjects: "Micromeasurements of Radio Frequency and its Applications."

### FORDHAM UNIVERSITY. Chemistry Department

Dr. George Antonoff was recently appointed Professor of Physical Chemistry. He took his degree in 1920 at the University of Manchester, and for many years maintained his own laboratories both in London and in Paris for industrial consulting work on the industrial applications of colloidal chemistry. He also carried out his own research work on surface tension and on the nature of liquids. He worked in Rutherford's laboratory in Manchester and in Cambridge investigating radioactive substances, especially radium D and uranium-Y, the latter of which he discovered.

Dr. F. F. Nord gave lectures at Iowa State College on low temperature phenomena in colloid chemistry and on the enzyme system of Fusaria and its action. He also addressed the organic chemistry seminar at Columbia University.

Rev. Francis W. Power, S.J., addressed the Baskerville Chemistry Society at the College of the City of New York on detoxication mechanisms, and the Newman Club at Hunter College (Bronx) on the religion of some of the great scientists of the past and of today. He also reported to the Secchi Academy at Georgetown University on the results of some new random sampling experiments done in connection with the statistical study of 349 carbon and hydrogen determinations which recently appeared in the Analytical Edition of Industrial and Engineering Chemistry. Vol. 11, No. 12, pages 660-673.

Dr. Walter A. Hynes and Dr. Leo K. Yanowski are preparing a review article for Mikrochemie dealing with the analytical properties of certain of the cobalt complexes.

Dr. Douglas J. Hennessy has been receiving many visitors from various industrial research laboratories who have come to inspect the new model fluorophotometer he has developed for use in vitamin assays.

Dr. Jakob A. Stekol has been asked to write the next review article on Detoxication for the Annual Review of Biochemistry.

Dr. William J. Conway addressed the New England Chemistry teachers' Association at Holy Cross College, Worcester, Mass., on the subject of effective demonstration experiments in General Chem-

istry. He also spoke before the Association of Chemistry Teachers in Catholic Schools at the Catholic University of America. Dr. Conway has developed a popular lecture-demonstration on chemistry for non-technical audiences which has proved very successful and is in constant demand.

### FORDHAM UNIVERSITY. Biology Department

Colchicine is a chemical substance which when applied to certain plants causes an increase in the number of chromosomes. Some of our graduate students are conducting such experiments, along with others in our greenhouse.

Our newly established unit of physiology is making steps that indicate great progress in the near future.

There have been many requests for the program of our graduate seminars, received from various places throughout the west.

The "Fordham Mitosis Model" patent is now being applied for in Washington, D. C.

An attempt is being made to clear up the confusion that now exists in the method of reproduction in Amoeba Proteus.

#### Physics Department

On Friday, February 2nd, Father J. Joseph Lynch received his degree of Doctor of Philosophy in Physics at New York University.

On February 21, Father J. Joseph Lynch gave a lecture at New York University on the topic: "Church and Science." At the request of Dodd, Mead & Co., Father Lynch will publish a book on: "Popular Seismology." Dr. Hess delivered lectures on the subject of Cosmic Rays at Princeton University, Yale University and Purdue University.

### CANISIUS COLLEGE. Biology Department

Rev. John A. Frisch published a paper, entitled: "The Experimental Adaptation of Paramecium to Sea Water," in the *Archiv für Protistenkunde*, Vol. 93 (1) pp. 39 - 71.

### BOSTON COLLEGE. Physics Department

To insure an adequate supply of water at a constant temperature to be supplied at a constant rate, in the Cellendar and Barnes continuous flow method of determining the mechanical equivalent of heat, we invested a dollar in an old automobile gasoline tank and found that if the water is placed in the tank the day before, the water has a constant temperature.

The concentric interference patterns formed by the Fabry and Perot Etalon are now being studied in a strong magnetic field. The separate interference patterns for each line give a source for study

of the Zeeman effect. The yellow line from a Helium tube was studied. In one the early issues of the American Physic Teacher there will be an article by F. M. Gager of the Staff on "e/m thermionically measured." The program of the Physics Seminars has been published. The topics that have been discussed with great interest were, 'Electron Microscope'; 'Flashlight Photography'; 'Teletypewriters'; 'Cold Light'; 'Armstrong Frequency Modulation'; 'Cosmic Ray Telescopes'; and 'Sound Recordings'. Three of the graduate students are giving their results of applying Milnes Method of Numerical Integration of differential equations to Schrödinger's Equation.

## HOLY CROSS COLLEGE. Chemistry Department

On February 6th, Mr. William T. Levitt of Tamworth Associates, Inc., Needham Heights, Mass., gave a demonstration of glass-blowing.

A film on the manufacture of laboratory glassware will be shown to the members of the glass-blowing course, on March 5th by the courtesy of the Corning Glass Works, Corning, N. Y.

On March 12, Mr. A. C. Frey, manager of the Worcester Gas Light Co., will lecture on the subject: "Illuminating Gas." The same corporation is sending a glass enclosed working unit of the Servel Electrolux Refrigerator which will be demonstrated here for several weeks.

### Physics Department

When Father Michael J. Ahearn, S.J., was stationed at Holy Cross College many years ago, he carefully built up and classified a valuable collection of geological specimens.

Some years later it became imperative to remove the geological museum from its site in Beaven Hall in order to make room for a rapidly expanding biology department. Unfortunately, in the process of removal and storage, quite a number of the cards identifying the various specimens were either lost or misplaced.

Mr. Donald F. Grady, S.J., started early last September the tedious task of once again arranging the specimens in cabinets and, when possible, placing them in the original geological display cases. Thanks to the generous work of Mr. Grady and at the expense of hundreds of hours of his spare time, the collection is once again in good shape.

Father Daniel Linehan, S.J., on a recent visit to Holy Cross College, was kind enough to settle a few points still in doubt in the identification of the specimens. Father Ahern is to visit us in the near future to clear up any remaining points in the identification of the specimens.

In addition to the collection of specimens embracing crystals, minerals, rocks, fossils, samples of borings in the neighborhood of

the college, and examples of geological agencies and their work, there exists a fine collection of Bulletins of the United States and state Geological Surveys, monographs on geology and kindred subjects, maps, Yearly Reports of the Minerals of the United States, Annual Reports of the Smithsonian Institute and its famous "Miscellaneous Collections" and Bulletins of the U. S. National Museum at Washington, D. C.

In the annual report of the President of The Johns Hopkins University for 1938-1939 page 37, in the section on Departmental Activities and Publications of the Faculty of Philosophy, is included the following item:

"The Rev. T. H. Quigley, S.J., has studied the acoustic properties of air and of methane as a function of temperature, using for the purpose the principle of the *fixed path* Acoustic interferometer, developed in this (Johns Hopkins University Physics) laboratory."

# OFFICIAL ANNOUNCEMENT

# NATIONAL SCIENCE CONVENTION

CONTRIBUTION OF SCIENCE
TO THE QUADRICENTENNIAL CELEBRATION
OF THE SOCIETY

**September 4 - 5 - 6, 1940**

Location of Meeting will be announced in the next issue.

All the Provinces in the United States are invited to attend.

California Province
Maryland - New York Province
New Orleans Province
Chicago Province
Missouri Province
New England Province
Oregon Province

President: Rev. Richard B. Schmitt, S.J.
Loyola College, 4501 N. Charles Street,
Baltimore, Maryland.

Secretary: Rev. Emeran J. Kolkmeyer, S.J.,
Canisius College, 2001 Main Street,
Buffalo, New York.

Meeting of the American Chemical Society
Detroit, Michigan; Sept. 9 to 13, 1940.

# SCIENTIFIC BOOKS

Written by Members of the Society.

## SUBJECTS

| | |
|---|---|
| ANTHROPOLOGY | GEOLOGY |
| ASTRONOMY | MATHEMATICS |
| BIOLOGY | METEOROLOGY |
| CHEMISTRY | PHYSICS |
| SEISMOLOGY | |

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